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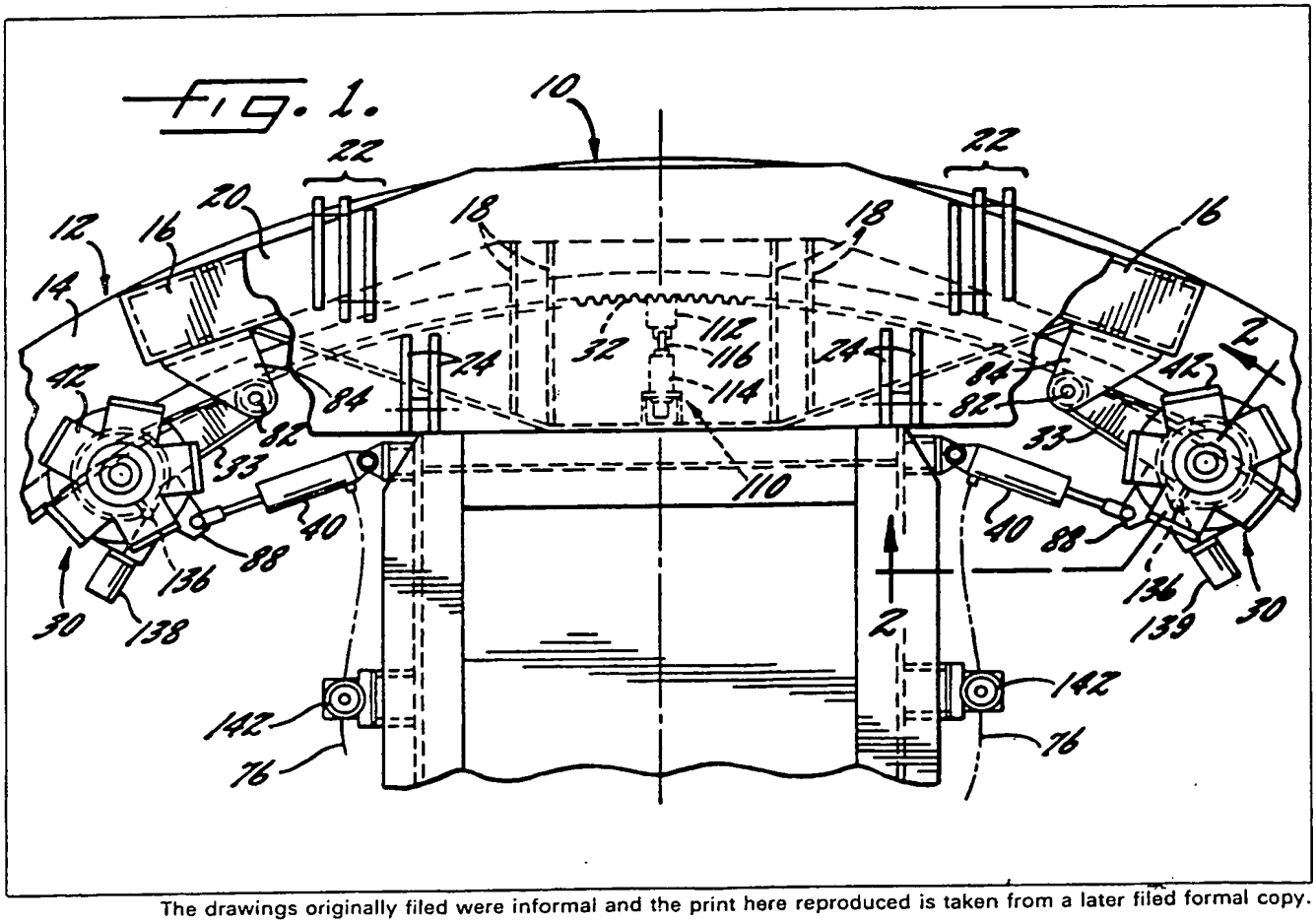
(54) Swing drive assembly with parking brake

(57) A swing drive assembly for a large load handling device (10) includes at least one hydraulically driven pinion (34) biased against a segmented ring gear (32) by a hydraulic actuator (40), a roller (38) engaging a guide flange (36) on the ring gear (32) to ensure constant backlash on the pinion (34) by regulating the extent of engagment of the respective teeth. A temporary parking brake (130, 134) is provided for each pinion and a hydraulic accumulator (142) maintains pressure in the actuator even when the pumps are shut down. A mechanical swing lock (112) is provided to prevent rotation for longer periods of time and, in the alternative, the drive pinions, if desired, may be permitted to "free wheel" without generating excessive back pressure.



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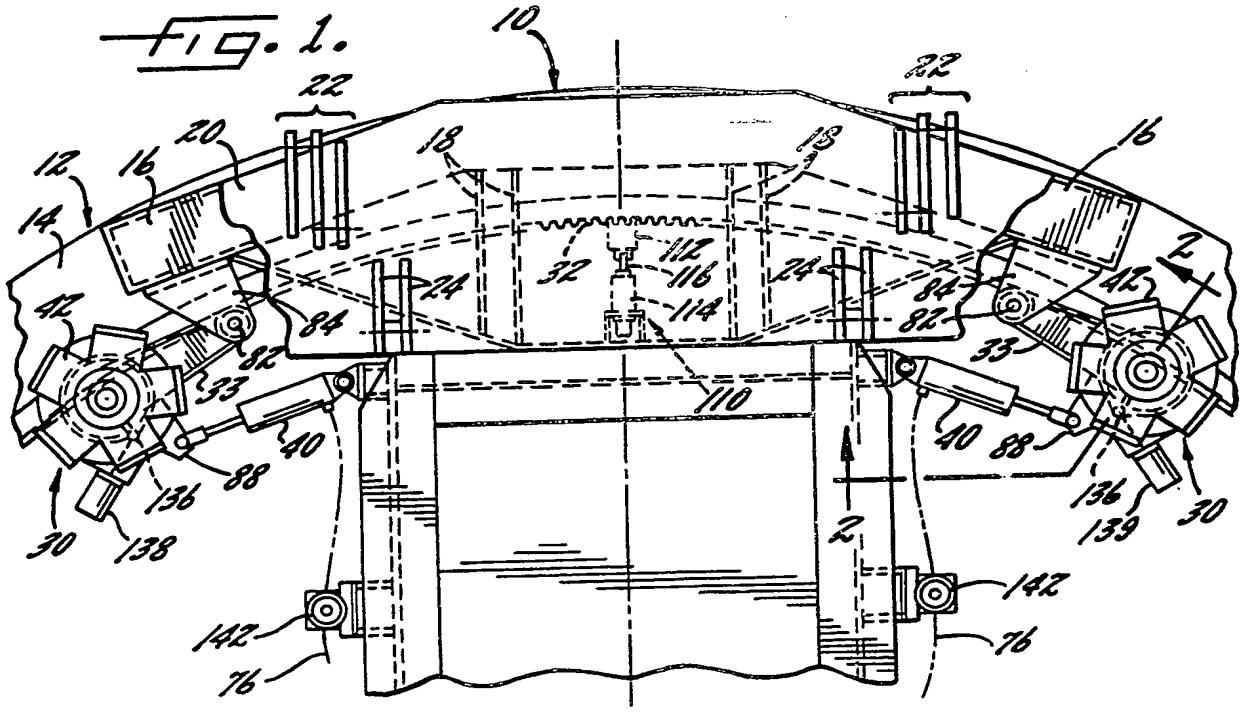
The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

Fig. 1.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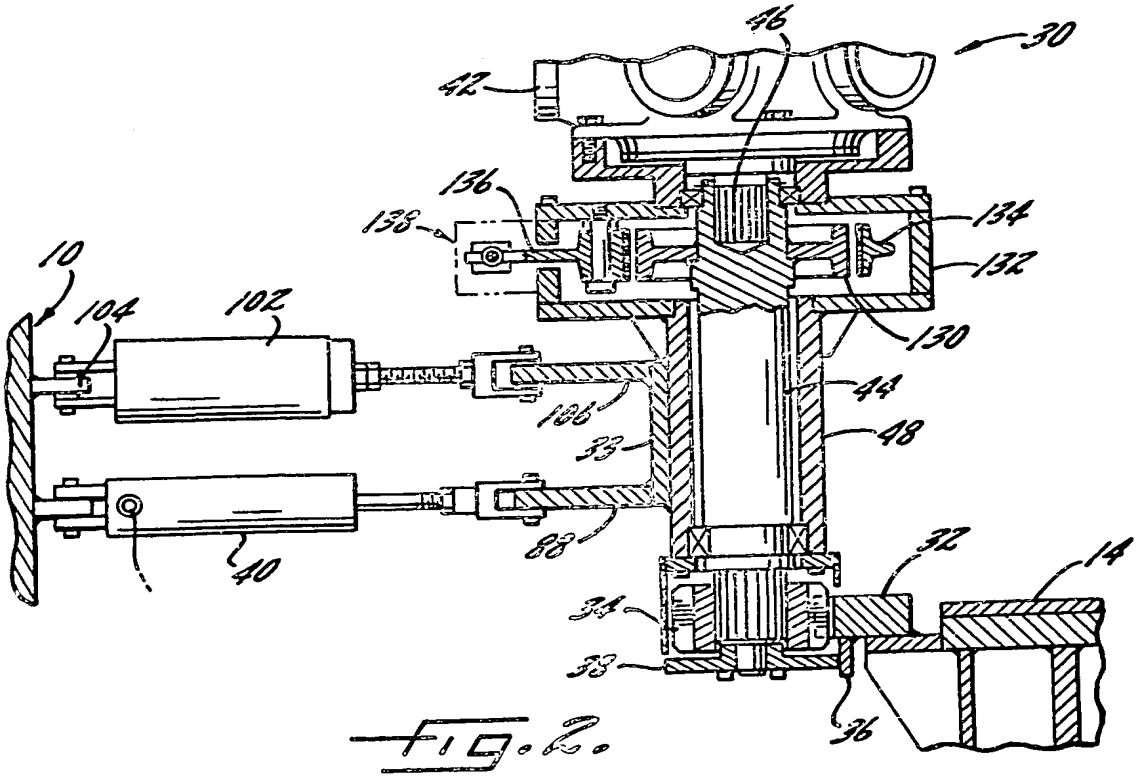
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Fig. 2.

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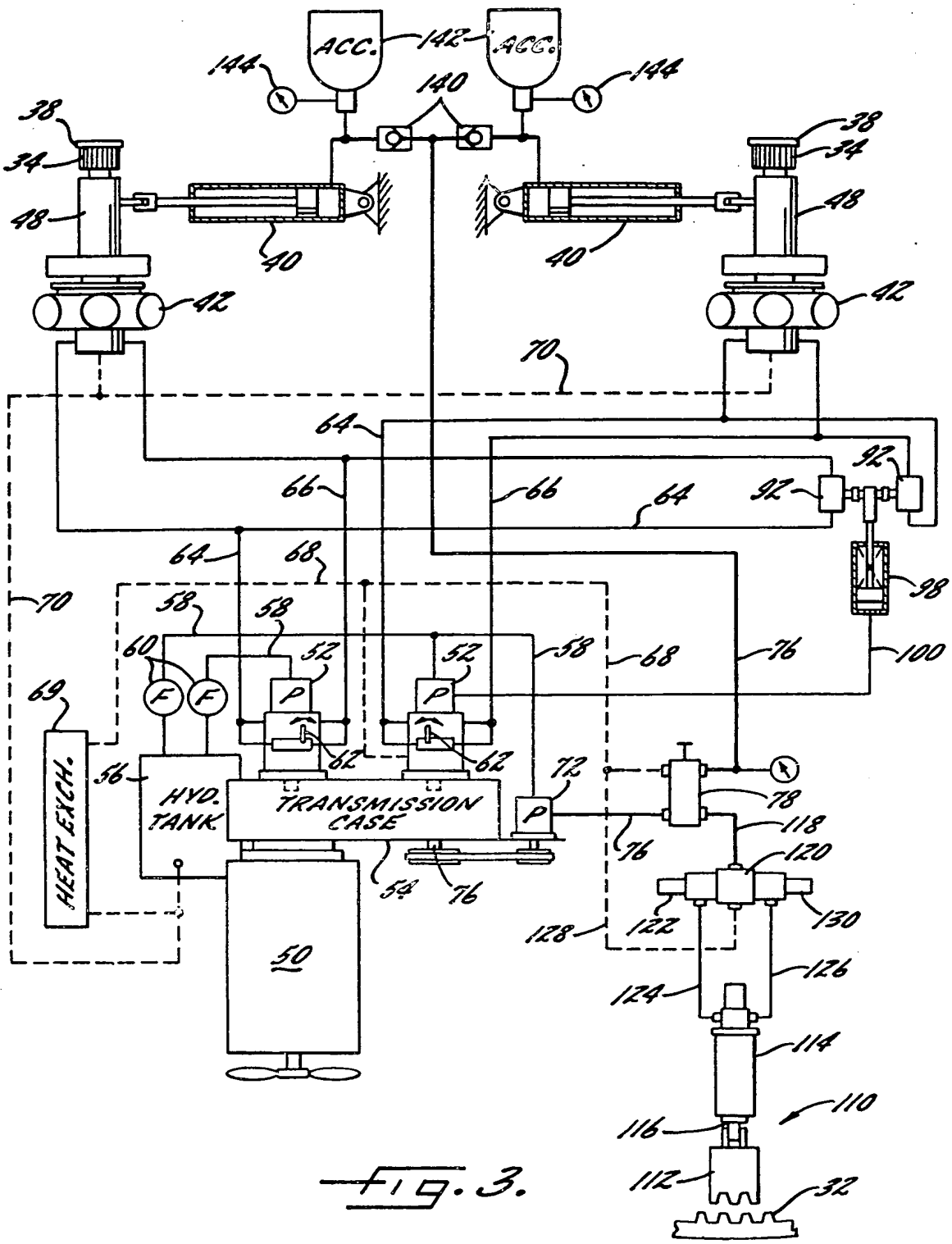

Fig. 3.

SPECIFICATION

Swing drive assembly with parking brake

The present invention relates generally to load handling devices and more particularly concerns an improved swing drive and parking brake assembly for large load handling cranes and the like.

It is known in the art that the lifting capacity of a load handling device, such as a crane, can be increased by providing the device with a large diameter roller path for supporting on rollers an opposed boom and a counterweight assembly. One example of such a device is shown in U.S. patent No. 3,485,383. A similar device is disclosed in U.S. patent No. 4,013,174, which also discloses a swing drive assembly with automatic shut-down control which permits free swinging of the crane upper works due to wind induced rotational forces when the engine is sut down.

It is the primary object of the present ivention to provide an improved swing drive assembly of the type disclosed in U.S. patent No. 4,013,174, which is incorporated herein by reference, including parking brake means to prevent rotation of the swing drive assembly when the crane engine is temporarily shut off. The present invention also includes hydraulic accumulator means for maintaining pressure in the hydraulic actuators which bias the swing drive pinions into engagement with the ring gear even when the crane engine is shut off. A mechanical swing lock may also be provided to lock the crane upper works against rotation for longer periods of down time.

In the accompanying drawings:—

Figure 1 is a fragmentary plan view of a portion of the upper works of a crane with which the improved swing drive assembly of the present invention is associated;

Figure 2 is an enalrged vertical section substantially as seen along the line 2–2 in Fig. 1; and

Figure 3 is a schematic diagram of the hydraulic circuit for the improved swing drive assembly of the present invention.

Turning now to the drawings, there is shown in Fig. 1 a portion of the upper works, in the form of a boom carrier, indicated generally at 10, of a large load handling device such as, for example, a heavy duty lift crane. Such a lift crane is disclosed in U.S. patent No. 4,013,174, which is incorporated herein by reference, and reference may be made to that patent for further details of the upper works of a crane of the type with which the present invention is associated. As also disclosed in the aforementioned patent, the crane is provided with lower works which includes a large diameter ring 12 and roller path 14 for supporting the boom carrier 10 on rollers (not shown).

The forward end of the boom carrier 10 is formed of a generally box-shaped beam with laterally extending wings 16 which, with intermediate framing 18, support a carrier plate 20 on which the crane boom and mast (neither shown) are pivotally mounted in connecting plates such as 22 and 24, respectively.

For rotating the boom carrier 10 relative to the ring 12, one or more swing drive assemblies 30 are provided. In the illustrated embodiment shown in Figs. 1 and 2, an internally toothed ring gear 32 is rigidly secured on the inner periphery of the roller path 14 and the boom carrier 10, which acts as a frame element, carries a pivotal link 33 (for each drive assembly 30) which supports a drive pinion 34 journalled for engagement with the ring gear 32. Concentric with the ring gear 32, a guide flange 36 is mounted on the inner periphery of the roller path 14 and a guide roller 38 is mounted concentric with the pinion 34.

Hydraulic actuator means 40 are provided for urging the pinion 34 into engagement with the ring gear 32 and the guide roller 38 into engagement with the guide flange 36 during normal swing operation. By properly dimensioning the diameter of the guide roller 38 relative to the depth of the teeth on the pinion 34 and the ring gear 32, the extent of engagement of the respective teeth can regulated so as to maintain the backlash on the pionio 34 substantially constant regardless of eccentricities or other irregularities in the formation of the ring gear 32. Accordingly, the roller path 14 and the ring gear 32 may be formed of a plurality of arcuate segments bolted or otherwise rigidly secured together at the job site. The guide flange 36 may also be formed in arcuate segments but, preferably, it is rigidly and accurately secured to its companion ring gear segment such as by welding.

It will also be understood that since the guide roller 38 maintains the engagement of the teeth on the pinion 34 and ring gear 32 substantially constant, precision machining of the ring gear teeth close tolerances is not essential. Rather, the ring gear teeth may be cut with reasonable accuracy even by current flame-torch cutting techniques. Moreover, while the ring gear 32 and guide flange 36 are shown in the illustrated embodiment secured to the inner periphery of the roller path 14, it should be appreciated that they could be secured to the outer periphery. In that case, of course, the pinion 34 and the guide roller 38 would likewise be urged inwardly into respective engagement with the ring gear 32 and the guide flange 36.

SWING DRIVE

For driving each of the pinions 34, a reversible hydraulic motor 42 is supported by the

links 33 and a pinion drive shaft 44 is splined to the output shaft 46 of the motor 42. The shaft 44 is journalled in bearings mounted in a housing 48 at the free end of the link 33 (see Fig. 2).

Referring now to Fig. 3, there is shown a schematic diagram of the power source and hydraulic circuit for driving the swing drive motors 42. The power source preferably includes an internal combustion engine 50 which drives a pair of variable displacement, reversible output pumps 52 though a transmission casing 54. Hydraulic fluid is drawn by the pumps 52 from a tank 56 through supply lines 58 each having a filter 60 therein. Each of the pumps 52 has a control 62 for regulating the pump displacement and the direction of discharge through reversible supply/return lines 64, 66 coupled to each of the motors 42. The casing of each of the pumps 52 also drains to a sump line 68 connected to the tank 56 and has a heat excahnger 69 therein. A return line 70 is also provided to drain oil leakage from the casings of the motors 42.

To supply fluid to the actuators 40, the engine 50 also drives a fixed displacement pump 72 from an output shaft 74 on the transmission casing 54. The pump 72 draws fluid from the tank 56 through one of the supply lines 58 and delivers fluid to the actuators 40 through a delivery line 76. A pressure relief valve 78 is connected to the delivery line 76 so that the pressure delivered to the actuators 40 is maintained constant when the swing drive assembly is in operation. Excess pressure from the relief valve 78 discharges into the sump line 68.

Returning to the embodiment shown in Fig. 1, each of the links 33 is pinned at 82 on a bracket 84 secured to one of the wings 16. Referring also to Fig. 1, the actuator 40 is pinned at one end to a lug 88 on the housing 48. Preferably the link 33 is disposed substantially tangentially to the pitch line of the pinion 34 and ring gear 32 so that the driving force is imparted essentially through the axis of the pin 82 in the bracket 84. While two swing drive assemblies 30 are shown in the illustrated embodiment supported by links 33 pivoted to brackets 84 on the boom carrier 10, it will be appreciated that additional swing drives 30 may be mounted on other frame elements (such as a counterweight carrier, not shown) extending outwardly from the upper works of the crane to adjacent the roller path 14.

FREE SWINGING

As pointed out in the aforementioned U.S. patent No. 4,013.174, the upper works of the crane, particularly the boom and mast, present a considerable area against which the wind impinges. When the wind direction changes, especially during gusty periods, it creates a substantial force on the upper works, including the boom carrier 10, tending to rotate it about the ring 12 somewhat like a huge weather vane. This wind induced rotational force is opposed by the torque generated in the motors 42 as the pinions 34 are rotated around the ring gear 32. Under these conditions, of course, it will be understood that the motors 42 actually operate as pumps and the opposing torque is dependent on the pressure generated internally in the motors 42 and in the reversible lines 64, 66. If flow through these lines is effectively blocked, for example, by the pumps 52 which are coupled through the transmission casing 54 to the engine 50, tremendous back pressure builds up in the lines 64, 66 and the rotation opposing torque exerted by the pinions 34 on the ring gear 32 is very high. This, in turn, creates large separation forces between the teeth of the pinions 34 and ring gear 32 and, unless relieved, can cause tooth breakage and/or uneven and rapid wear due to partial tooth seperation at high loads.

In the illustrated embodiment, means are provided for reducing the back pressure in lines 64, 66 and thus the wind induced torque applied to the pinions 34 when the engine 50 and pumps 52 are shut down. For this purpose, by-pass valves 92 are connected to lines 64 and 66, respectively, to shunt the flow of hydraulic fluid around the pumps 52 when the valves 92 are open. This greatly reduces the back pressure in the lines 64 and 66 to a level dependent only upon their internal flow restrictions. Consequently, the opposing torque of the pinions 34 and forces tending to seperate them from the ring gear 32 are also significantly reduced.

When the engine 50 is shut down, the valves 92 are automatically biased to the open position. As shown in Fig. 3, a spring biased actuator 98 is provided having its piston rod end connected to the valves 92 so as to normally move them to the open position. The cylinder end of the actuator is connected by a line 100 to receive charge pressure from one of the pumps 52 when it is operated by the motor 50. Pressure in the cylinder end of the actuator 98 compresses the spring and moves the by-pass vlaves 92 to the closed position. This places the pumps 52 in direct communication with the motors 42 for normal swing drive operation as previously described.

During free swinging, means are also provided for maintaining the pinions 34 in constant mesh with the ring gear 32 when the engine 50 and pumps 52 are shut down. To this end, a spring 102 is interposed between the boom carrier 10 and the housing 48 of the swing drive assembly 30 (see Fig. 2). The spring 102 serves to bias the pinion 34 toward the ring gear 32 and the guide roller 38 into engagement with guide flange 36.

Preferably, the spring 102 is mounted above and parallel to the actuator 40 by means of lugs 104 to 106 on the boom carrier 10 and the housing 48, respectively. It should be understood, however, that this mounting arrangement could be modified or even reversed to suit the space available on a particular machine. It will also be appreciated that because the vlaves 92 are opened, when the engine 50 is shut down, the torque and the seperating forces on the pinions 34 are reduced and therefore the counteracting force required by the springs 102 is only a fraction of the force imposed by the hydraulic actuators 49 during normal swing drive operation.

SWING LOCK

If free swinging of the crane upper works is not desired, the boom carrier 10 may be mechanically locked to the ring 12. For this purpose, a swing lock actuator 110 is provided for advancing and retracing a toothed gear segment 112 into and out of engagement with the teeth of the ring gear 32. In the preferred embodiment, the swing lock actuator 110 includes a reversible rotary hydraulic motor 114 which turns an axial screw mechnaism 116 to move the gear segment 112 into and out of engagement with the ring gear 32. It will be appreciated that when the teeth of the gear segment 112 and ring gear 32 are engaged, the upper works of the crane is locked against rotation on the ring 12. While one or more swing lock actuators 110 could be located almost anywhere on the crane upper works adjacent the ring 12, a single actuator 110 has been illustrated here as being mounted on the boom carrier 10 (see Fig. 1).

To power the swing lock actuator 110, hydraulic fluid is delivered through a line 118 from a port in the adjustable relief valve 78 to the intake side of a spring centered two-way shuttle valve 120. When the shuttle valve 120 is in its centered or neutral position, flow through line 118 is blocked. When the shuttle valve 120 is moved in one direction (such as to the right in Fig. 3) by an actuator, for example an air cylinder 122) hydraulic fluid flows from line 118 through the valve into line 124 to one side of the screw motor 114 to advance the screw mechanism 116 and cause the gear segment 112 to mesh with the ring gear 32. Hydraulic fluid returns from the other side of the motor 114 through a line 126 to the shuttle valve 120 and out through a return line 128 connected to sump line 68. Conversely, when it is desired to unlock the gear segment 113 from the ring gear 32, the shuttle valve 120 is moved in the opposite direction by another air cylinder 130 which reverses the flow of hydraulic fluid through lines 124, 126 and causes the acrew mechanism 116 to retract the gear segment 112 from engagement with the ring gear 32. It will be appreciated, of course, that once the gear segment has been fully advanced or retracted, the shuttle valve 120 would be normally returned by its internal springs to its neutral position blocking line 118. Utilization of the swing lock actuator 110 may be desired, for example, when wind incuced loads are low and/or the crane is used to hold or apply a load for an extended period of time.

PARKING BRAKE

Pursuant to the present invention, means are also provided for temporarily preventing rotation of the crane upper works when the engine is shut off without energizing the swing lock actuator 110, as discussed above. Such temporary restraint may be desired when it is required to perform some fabrication of adjustment work on a suspended load or on the structure to which the load is to be secured.

As shown in Fig. 2, each of the swing drive units 30 includes a brake drum 130 mounted on the pinion drive shaft 44 within a protective housing 132. Surrounding the brake drum 130 is a brake band 134, one end of which is fixed to the housing 132 and the other end connected to an operating lever 136 for tightening the brake band 134 against the brake drum. The operating lever 136 is preferably connected through a mechanical linkage (not shown) to the piston end of a pneumatic cylinder 138 which may be selectively pressurized by the crane operator to apply the temporary parking brake. The cylinder 138 preferably includes an interal spring mechanism for expanding the brake band when the air cylinder is depressurized.

It is another feature of the invention that means are provided for maintaining pressure in the hydraulic actuators 40 during temporary shut down of the engine 50. As noted previously hydraulic fluid is supplied to the actuators by pump 72 through delivery line 76 and pressure relief valve 78. Also connected between the relief valve 78 and each of the actuators 40 is a check valve 140 and a hydraulic accumulator 142. The check valves 140 prevent reverse flow of hydraulic fluid even when the pump 72 is shut off and the accumulators 142 maintain hydraulic pressure in the actuators 40. The accumulators 142 preferably include a pre-charged bladder filled with an inert gas, such as nitrogen, to cushion and maintain pressure within the accumulators. A seperate pressure gauge 144 is also provided for each accumulator to register the pressure therein. Also the check valves 140 may be provided with a manual bypass to bleed pressure from the accumulators as may be required to permit safe service and repair of the system.

From the foregiong, it will be seen that the present invention provides an improved swing drive arrangement for heavy duty crane as-

semblies rotatably supported on large diameter roller paths. During normal swing drive a hydraulic actuator 40 urges a guide roller 38 into engagement with a guide flange 36 to provide substantially constant backlash of the pinion gear regardless of irregularities in the large ring gear 32. When the engine 50 is temporarily shut down, pressure is maintained in the actuators 40 by hydraulic accumulators 142 and check valves 140. Each of the swing drive assemblies 30 also includes a parking brake which may be applied to prevent rotation of the drive pinions 34 when the pumps 52 are shut down. For longer periods of non-use a mechanical swing lock actuator 110 is provided for engaging a toothed gear segment 112 with the teeth of the ring gear 32. Alternatively, if it is desired to permit the crane upperworks to free swing in the wind (or "weather vane") automatic bypass valves 92 open to shunt hydraulic fluid around the pumps 52 and thereby prevent excessive pressure from developing in the hydraulic supply/return lines 64, 66 as the pinions 34 rotate. A large compression spring 102 serves to hold each drive pinion 34 in engagement with the ring gear 32 even if the hydraulic system is shut down for a prolonged period of time.

CLAIMS

1. A swing drive assembly for a load handling device having upper works rotatably supported on a large ring roller path with a frame element mouneted on said upper works and extending outwardly therefrom to adjacent said roller path, a ring gear secured to one peripheral edge of said roller path, mounting means on said frame element for journalling a pinion gear for normal engagement with said ring gear and for moving said pinion gear toward and away from said ring gear, a guide flange mounted on said roller path concentric with said ring gear, a guide roller supported by said frame element and journalled for engagement with said flange, means including a reversible hydraulic motor for driving said pinion against said ring gear so as to swing said upper works on said roller path, a hydraulic actuator for urging said pinion toward said ring gear and said roller into engagement with said flange so as to maintain substantially constant backlash between said pinion and ring gear regardless of eccentricities in said roller path, hydraulic pump means for selectively pressurizing said motor and for constantly pressurizing said hydraulic actuator during normal swing drive operation, and hydraulic accumulator means for maintaining hydraulic fluid in said actuator means under pressure for urging said pinion toward said ring gear and said roller into engagement with said flange when said pump means is shut down.

2. A swing drive assembly as claimed in claim 1 including brake means connected to said pinion for restraining rotation thereof and means for selectively operating said brake means.

3. A swing drive assembly as claimed in claim 2 wherein said brake means includes a brake drum interposed between said motor and said pinion and including a brake band selectively engageable with said brake drum.

4. A swing drive assembly as claimed in claim 1 wherein said hydraulic accumulator means includes a pre-charged bladder of gas for maintaining pressure in said accumulator.

5. A swing drive assembly as claimed in claim 1 including check valve means interposed between said pump means and said accumulator means for preventing reverse flow of hydraulic fluid from said accumulator to said pump.

6. A swing drive assembly substantially as described with reference to, and as illustrated in, the accompanying drawings.

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